

# HOW CAN SOIL HEALTH MEASURES BE USED TO INFORM FARM MANAGEMENT?

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January 15, 2020

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# *Soil Health Is...*

*.... A Philosophy?*

*.... An End Point or a Journey?*

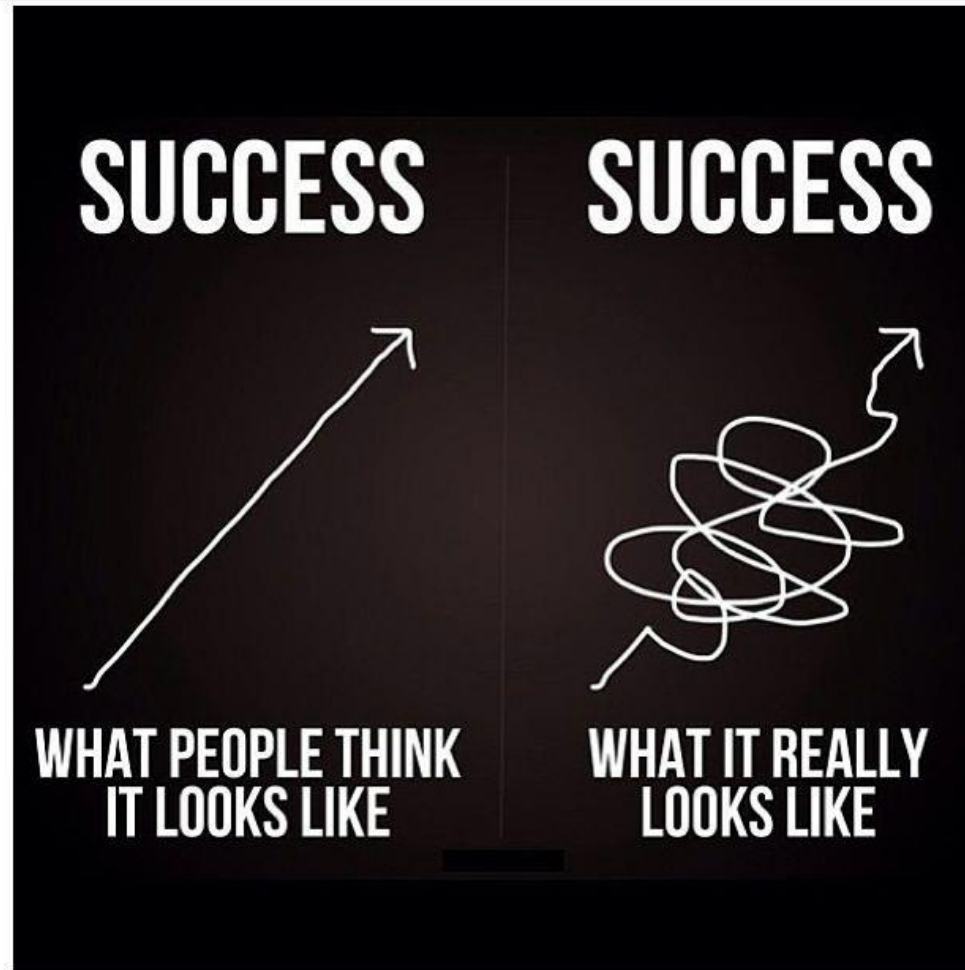
*.... Farm Practices and Management?*

*.... Measurements in the Field or Lab?*

*.... Feel-Good Marketing Fluff?*

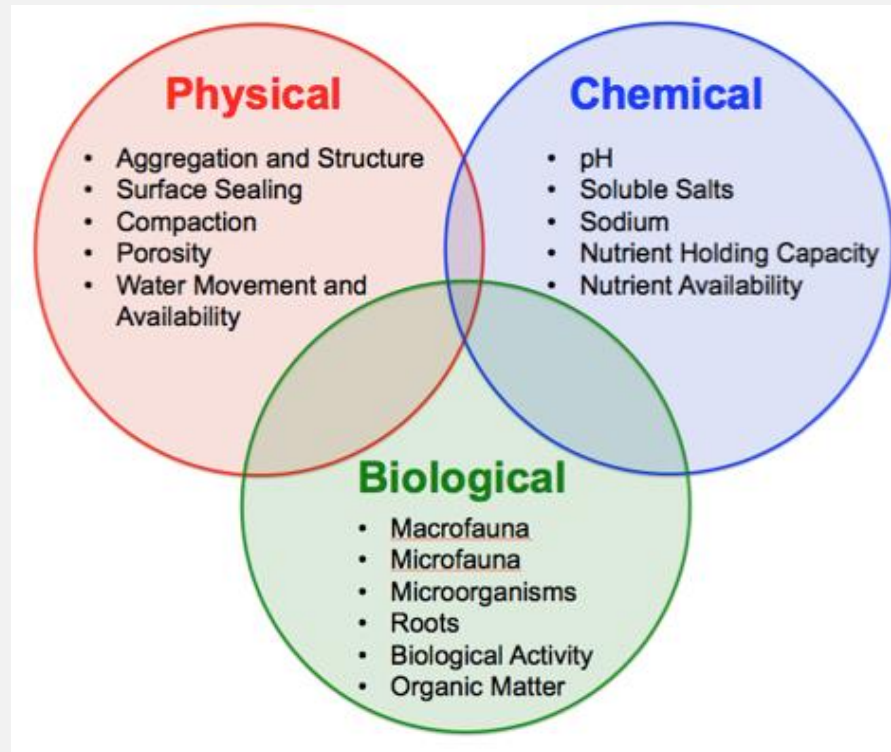
## *Soil Health Is...*

- A young and emerging field, needing refinement



# Soil Health Is...

- Multivariate by nature
  - Many properties that can be/ should be measured
  - Cannot sum it up with a single number




## *Soil Health Is...*

- Not an enterprise with a defined path or a known solution



Many possible roads with a common goal

# What does a healthy soil consist of?

- 
- Sufficient nutrients
  - Good tilth
  - Sufficient rooting depth
  - Good drainage
  - Few pathogens
  - Beneficial soil biota
  - Low weed pressure
  - No harmful chemical/toxins to crop
  - Resilience to degradation

*Soil Function → Soil Indicator*

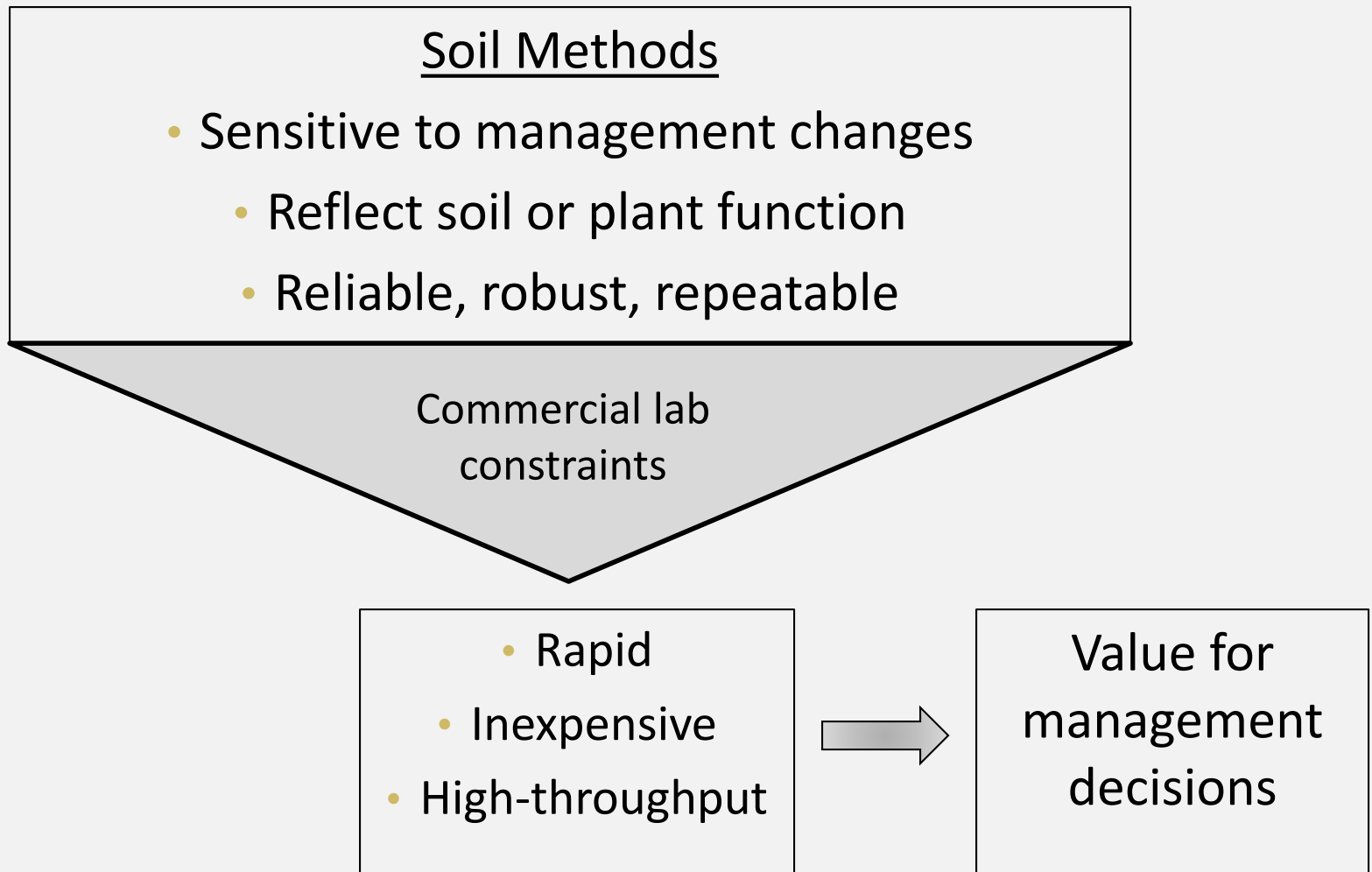
*If we want to manage it, we must be able to measure it!*

# There are many potential soil indicators

<b>Chemical Indicators</b>	<b>Physical Indicators</b>	<b>Biological Indicators</b>
Organic matter	Texture	Microbial biomass
Total C & N	Bulk density	Earthworms
pH	Penetration resistance	Nematodes
CEC	Aggregate stability	Arthropods
Nutrients	Water holding capacity	Mycorrhizal fungi
Electrical conductivity	Infiltration rate	Respiration rate
Heavy metals	Depth to hardpan	Soil enzyme activities
Other toxins	Depth to water table	Pollutant detoxification
	Erosive potential	Decomposition rates
	Aeration	Microbial community fingerprinting

*How do we pick the 'best' indicators?*

# Minimum Set of Indicators



# Key Soil Health Questions

- *What soil/ crop function does an indicator reflect?*
- *How do management practices influence soil health indicators?*
- *What's a good/bad value for a soil health indicator?*
  - *Wisconsin vs. Ohio?*
- *How do we standardize methods and scale up to commercial labs?*
- *How can we link soil health to crop productivity and farm profitability?*

# Organic Matter is Important (really, really important)

- The importance of soil organic matter in soil quality and functioning cannot be overstated
- Critical component that influences
  - Aggregation
  - Resistance to water and wind erosion
  - Bulk density
  - Root proliferation
  - Biological activity
  - Nutrient cycling and uptake
  - And more....
- Typically only makes up 1-6% of soil



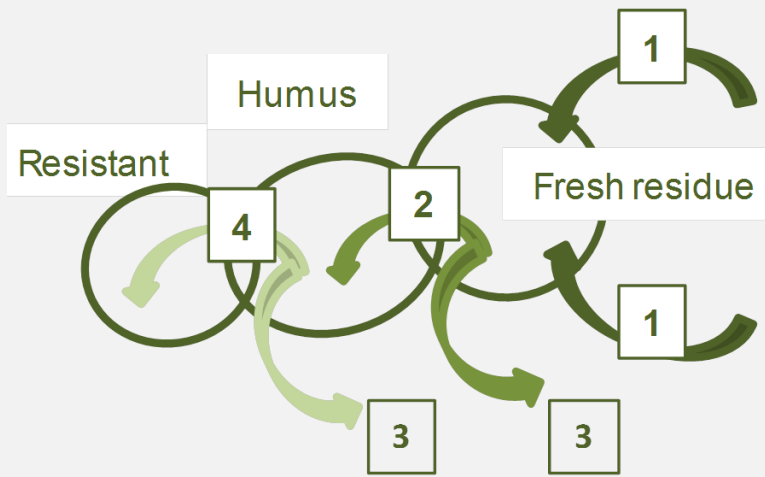
# Dynamic Nature of Soil Organic Matter

*It is the decay of organic matter, and not the mere presence of it, that gives 'life' to the soil.*

Cyril Hopkins, 1910

*Attempting to hoard as much organic matter as possible in the soil, like a miser hoarding gold, is not the correct answer. Organic matter functions mainly as it is decayed and destroyed. Its value lies in its dynamic nature.*

William Albrecht, 1938



# Stabilization vs. Mineralization

- Stabilization = nutrients from an inorganic form to an organic form (*Immobilization*)
  - Lock up in organic matter, not plant available
  - Process of building OM
- Mineralization = Convert OM from an organic form to an inorganic form (*Decomposition*)
  - Making nutrients plant available
  - Ex. Protein → Nitrate



Stabilization

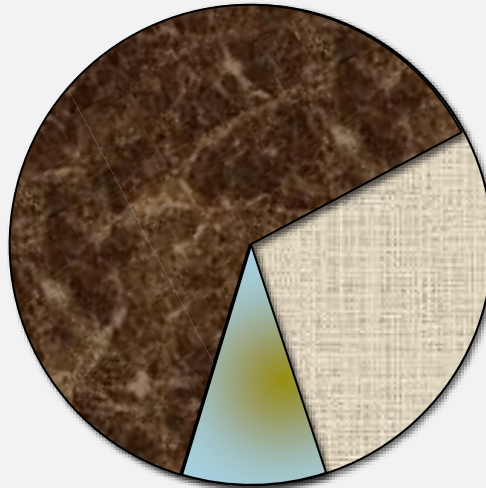
Mineralization



# 3 Pools of Organic Matter

## Passive

- Very stable organic material
- Extremely slow decomposition and cycling
- 60 – 80% of OM
- Turnover: decades - centuries



## Slow

- Intermediate organic material
- Slow decomposition and cycling
- 10 – 30% of OM
- Turnover: years - decades

## Active

- Recently deposited organic material
- Rapid decomposition and cycling
- 5-15% OM
- Turnover: days – few years

Active organic matter can be considered an integrator of soil biology and chemistry

# Function of 3 Organic Matter Pools

## Passive

- Water holding capacity
- Water infiltration
- CEC
- Chemically-protected nutrients



## Slow

- Physically-protected nutrients
- Water infiltration

## Active

- Available and rapidly cycled nutrients
- Microbial biomass, biologically active
- Initiation of aggregation

# How Does Active OM Increase Production Potential?

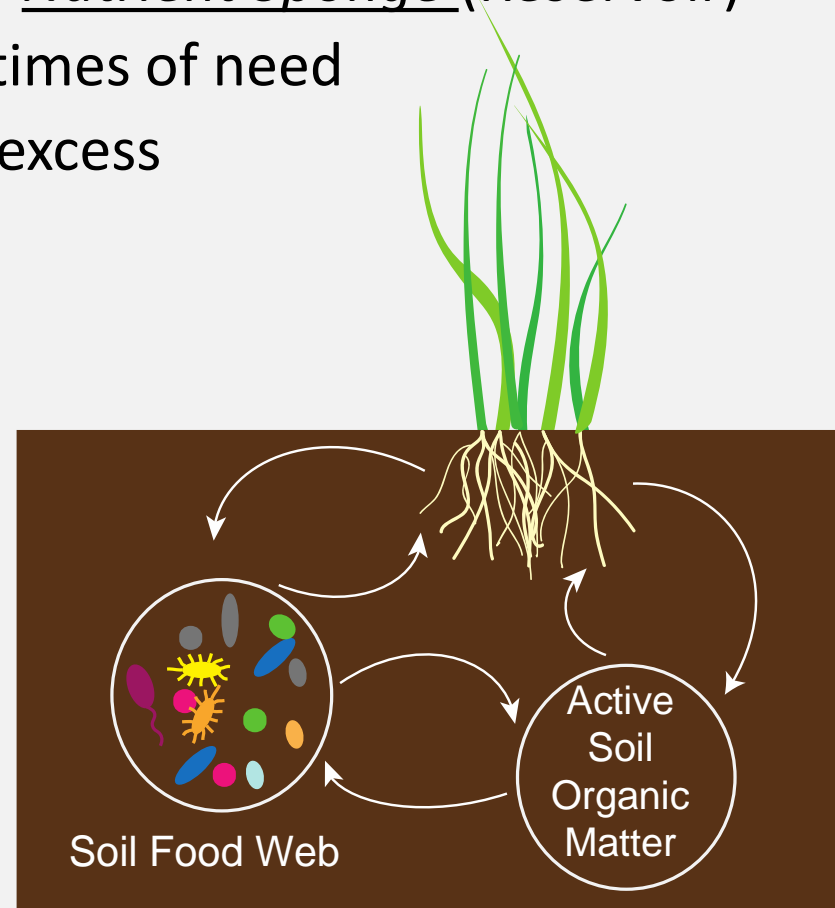
Active OM + Roots + Soil Food Web = Nutrient Sponge (Reservoir)

- Supplies nutrients to crops in times of need
- Locks up nutrients in times of excess
  - Reduces losses

As the soil food web becomes more developed (continuous supply of inputs, little disturbance)

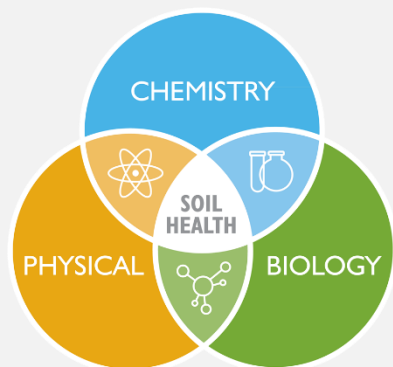
- More complex, diverse, resilient

Greater nutrient use efficiency

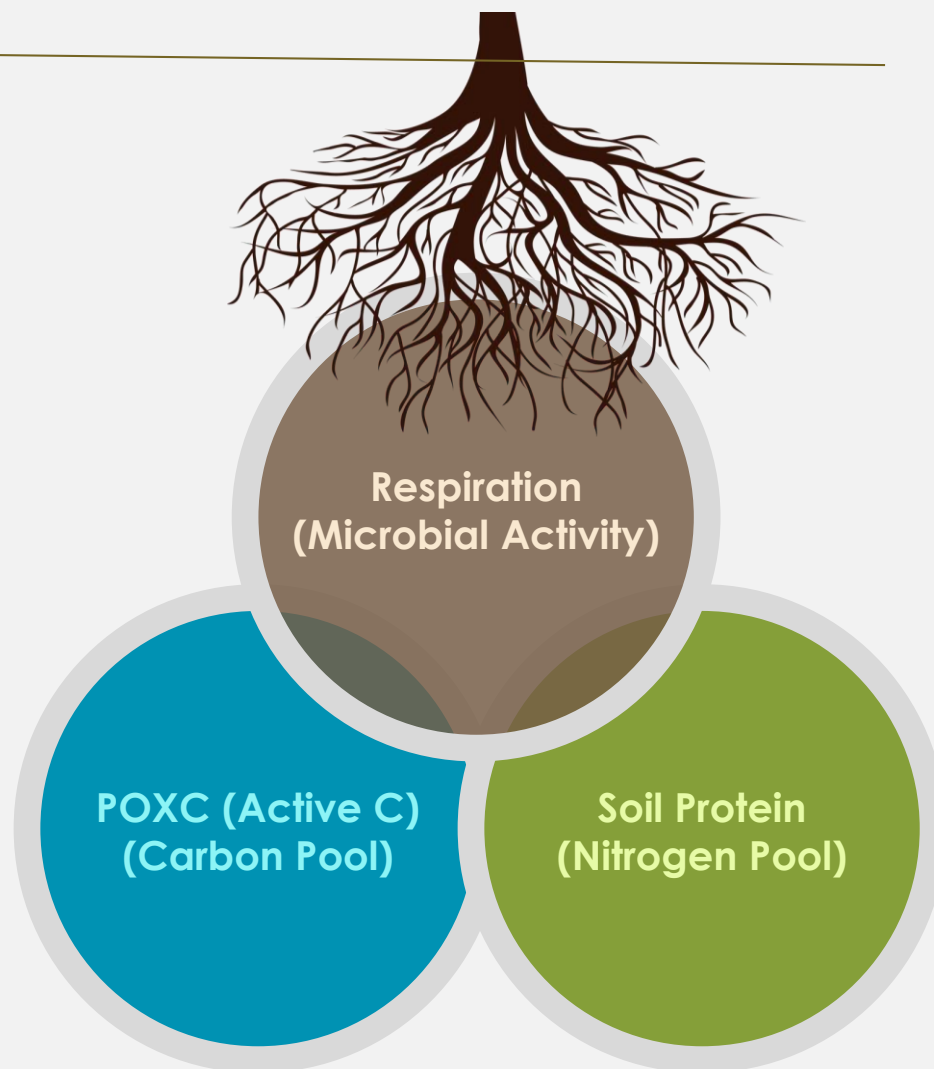


Can we measure active organic matter  
routinely and rapidly?

# Active Organic Matter Pools



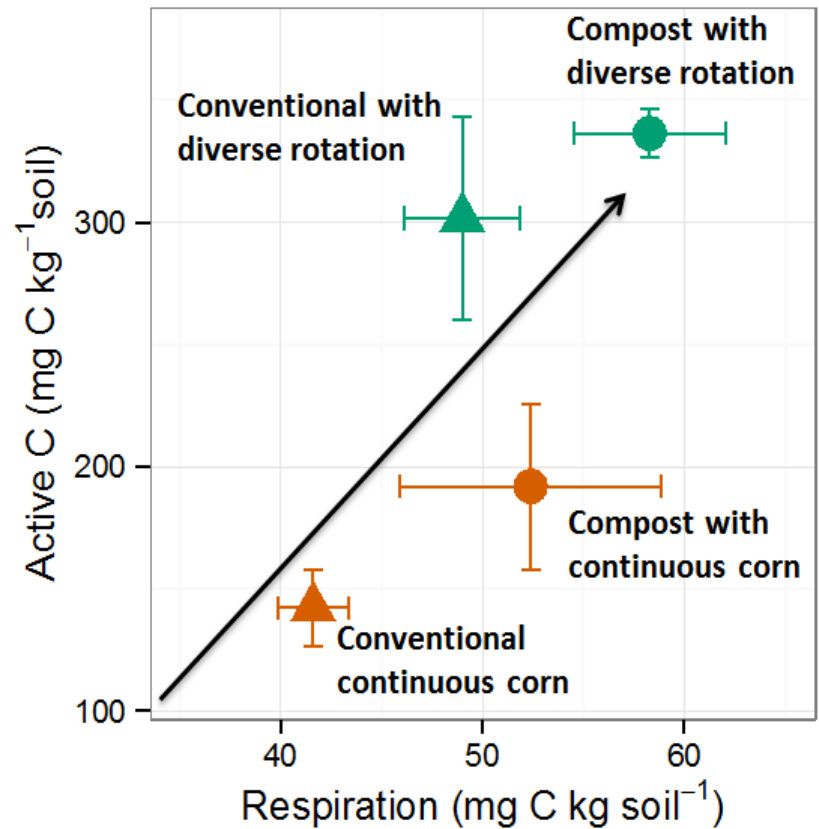
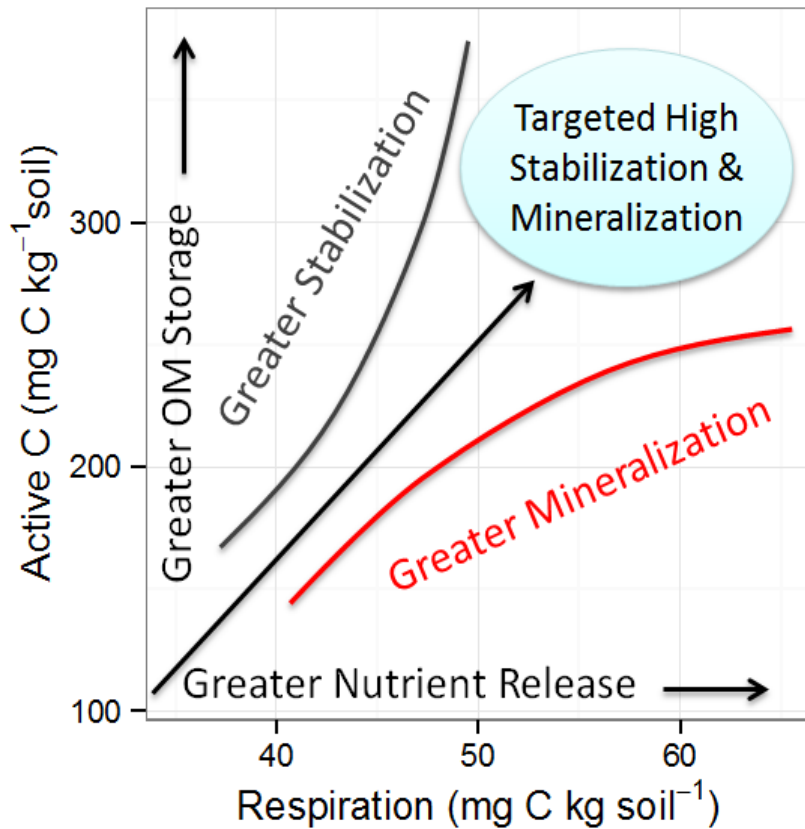
Process-based  
measurements  
of soil biology  
and chemistry



# *What soil function do the indicators reflect?*

- Measured active organic matter across many long-term studies across U.S. and found:
- Active C (POXC), Respiration and Protein are sensitive to past management practices (tillage practices, cover crops and crop diversity, manure applications)
- Influenced differently depending on management practice
- POXC = practices that build (stabilize) OM
- Respiration = practices that release (mineralize) OM

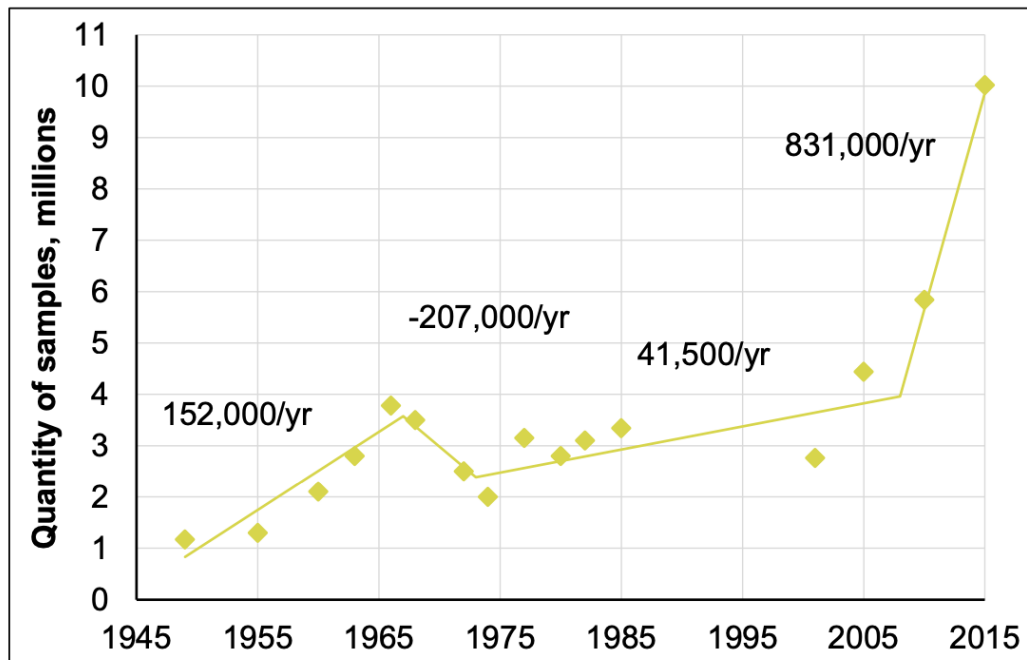
# Potential Soil Health Framework



*How do we scale up to commercial labs?*

# Soil samples analyzed for routine nutrient analysis

## Soil sample volume in the U.S.: 1949-2015



Cornell Soil Health  
2007 – 2015  
5767 samples  
( $<1\text{k}/\text{year}$ )

*Fine et al., 2017 SSSAJ*

How many have had soil health tests run?

# Soil Testing Infrastructure

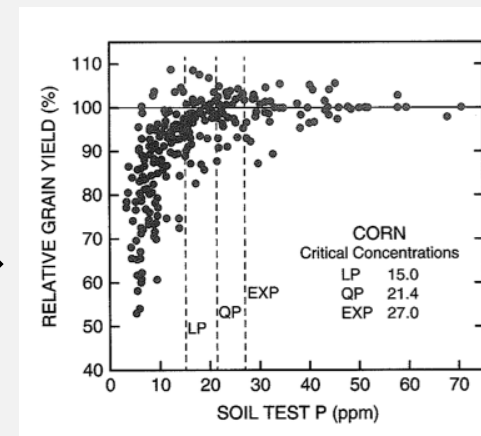
- Routine soil nutrient analysis
  - pH, OM, extractable nutrients



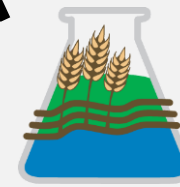
Collect Soil



Analyze Soil



Recommendation



QAQC

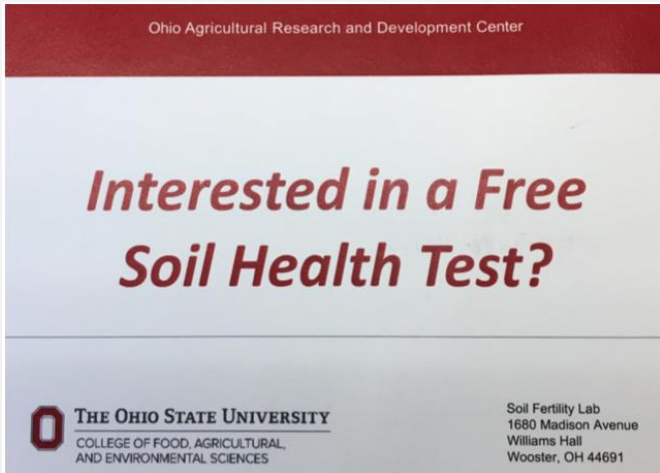
Soil health testing should  
complement existing soil testing to give  
farmers additional information

# *Assessing Variability of Indicators*

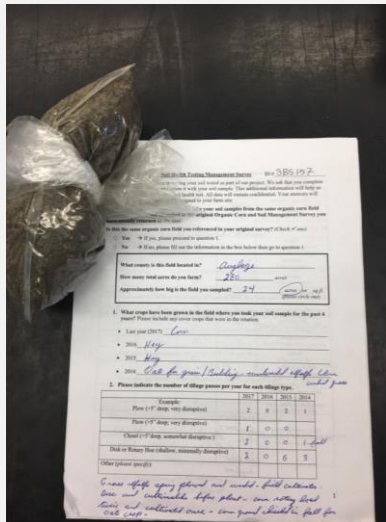
- Grid sampled corn fields in Ohio, multiple times per year
- Measured active organic matter and found:
  - Active OM indicator analytical variation:
    - Similar to total organic matter (LOI)
    - But greater than routine tests (pH, extractable P, K)
  - Temporal and spatial variability were comparable to routine tests
  - Suggests that we could routinely measure active organic matter indicators on the same soils and same densities as we sample for nutrient analysis

*What's a good/ bad indicator value?*

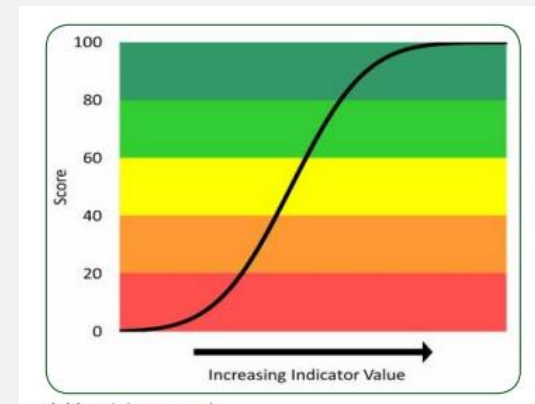
# On-Farm Soil Health Survey



- Farmers offered free soil health test, asked to submit soil sample
- Farmers mailed in soil with additional management information
- Soils analyzed for biological, physical, and chemical properties
- Distributions created by soil class (via CEC)

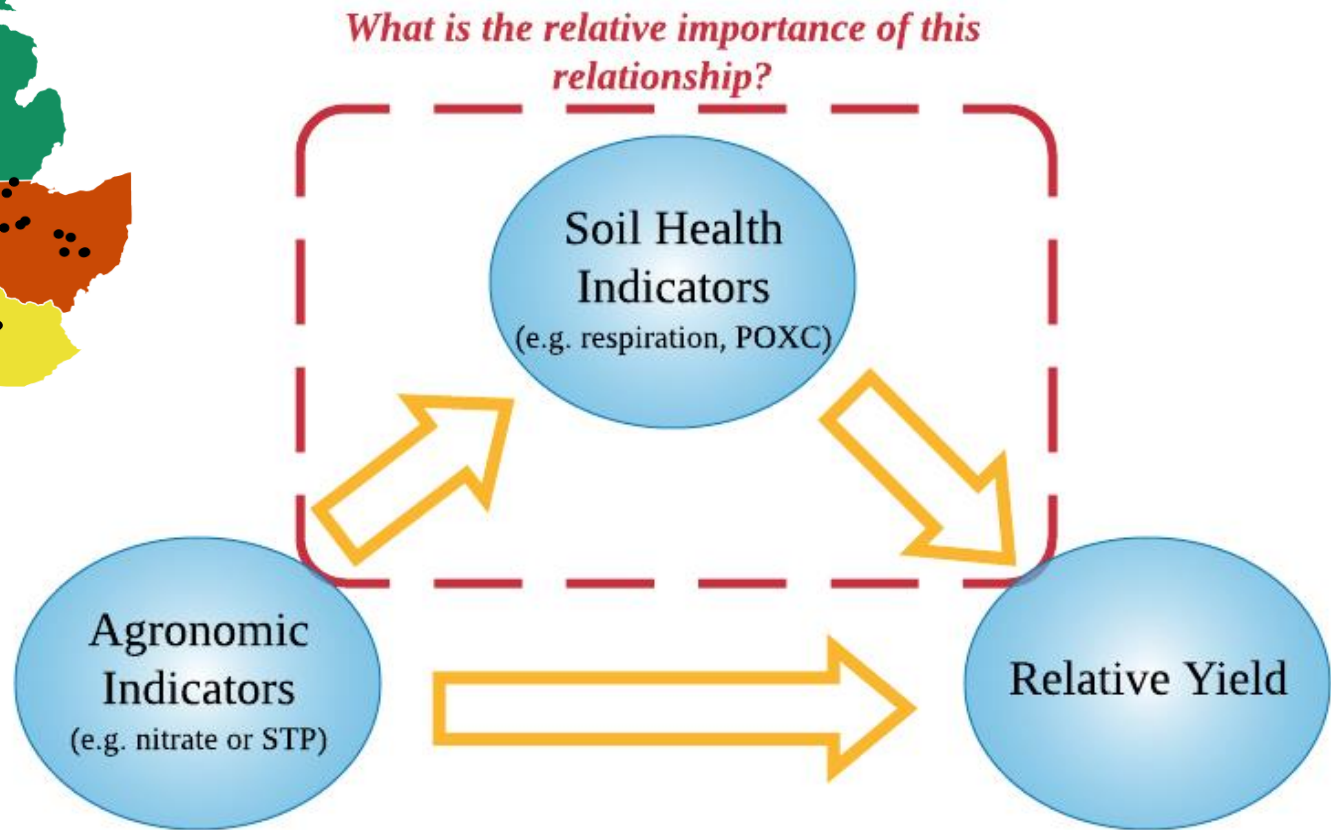
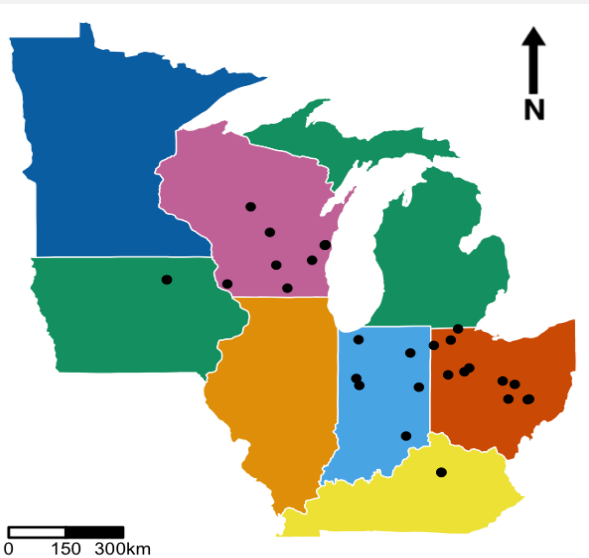


Sprunger, Culman, et al., unpublished



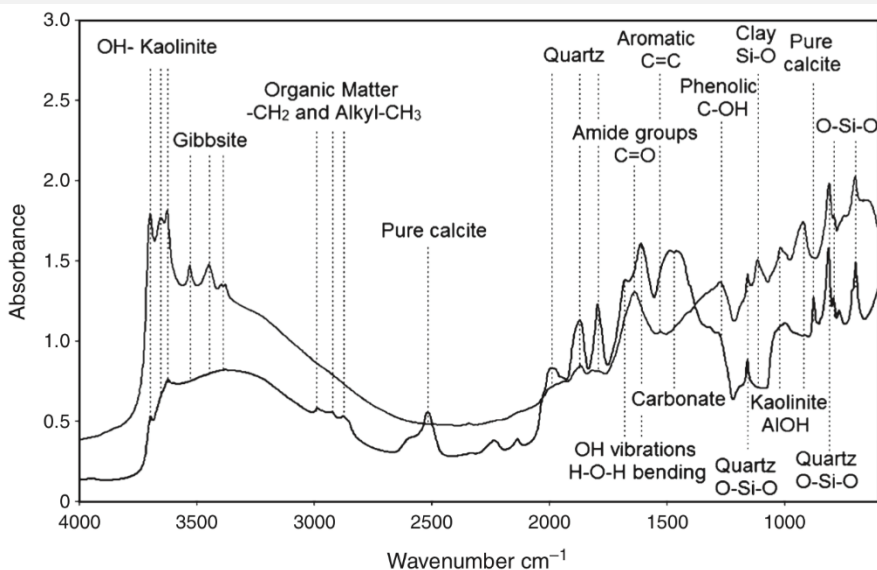
*How can we link soil health to  
crop productivity and farm profitability?*

# Does soil health lead to reduced fertilizer requirements?



# Infrared Spectroscopy (DRIFTS)

- Non-destructive, very rapid
- Measures reflectance of energy (reflected vs. absorbed)
- Can predict a wide range of soil properties



*Calderon, Culman, et al., 2017, SSSAJ; Deiss et al., unpublished*

# Steve's Soil Health Proclamation

- 1) Plenty of research has demonstrated management practices that improve or impair soils
- 2) These practices can sometimes (but not always) be at odds with a farmer's constraints (economics, time, knowledge, equipment, social acceptance, etc.)
- 3) Many soil properties can change slowly over time and are difficult to visually observe
- 4) Farmers need reliable and affordable tools to help them track and monitor soil properties in their fields
- 5) Meaningful tools will show farmers how their management decisions have impacted their soils and empower better soil management

# Thank You

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